ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • www.des.nh.gov

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# Disinfecting Public Water Systems

The purpose of this document is to provide a step-by-step outline for emergency disinfection of a public water system (PWS). The typical public water system targeted by this discussion would typically have a dug or bedrock well and relatively small atmospheric and pressure water storage tanks.

## ACTION PRIOR TO DISINFECTION

When water supplies have the presence of bacteria that are not due to sample error, the following initial actions need to be taken before disinfection.

### Inspect Facilities

Carefully inspect the water system facilities (i.e., wells, tanks) to identify the pathway(s) that allowed bacteria to enter the water system. See the DES fact sheets concerning recommended "Dug Well Design" (WD-DWGB-1-4) and "Bedrock Well Design" (WD-DWGB-1-2) on the webpage www.des.nh.gov/-organization/commissioner/pip/factsheets/dwgb/index.htm.

### Take Additional Bacteria Samples

Take additional bacteria samples from the well(s), storage tank(s), and various points in the distribution piping. These samples could possibly aid in determining the location where the bacteria first entered the water system. Remember that once the disinfection begins, all past bacterial evidence downstream of the point of disinfection will be killed. Failure to locate the point where the bacteria entered the water system and take corrective action potentially allows the contamination to reoccur.

### Flushing the System

The third step before adding a disinfectant is to flush the system. Chlorine is not able to kill bacteria entrapped within mud, rust, or other solids. In order to achieve total bacterial kill, all components of the system must be flushed to a clean condition. If you have already cleansed tanks or piping, it may not be necessary to repeat the process if you are sure that the interior conditions are clean.

> **Flushing Wells**: In dug wells, open the cover, look for poor construction, scrub the walls with a long handled brush and wash down. Flush the well to a clean condition by long duration pumping to waste. Also try to pump out accumulated sediments from the bottom of the well using a construction mud sucker type pump.
>
> In bedrock wells, the cascading water, caused by the drawdown of the water level in the well, will flush the inside of the well. Flush the well by long duration pumping to waste.

**Flushing Tanks**: If the storage tank has never been cleaned and if access to the inside of the tank is available, the inside of tank could be drained, the floor and walls scrubbed with a brush, and the inside washed down. If there are appreciable solids, try to collect them by shovel or scraper. Pump out the remaining muddy water. Do not let this muddy water drain into streams or ponds. If access to the inside of the tank is unavailable, try hosing down the inside through the top air vent. This may require unscrewing the vent pipe or removing the water level detection mechanism. If plumbing unions/fittings exist on the feed and withdrawal lines at the bottom of the tank, a flushing hose could be inserted along the tank bottom to loosen accumulated solids.

**Flushing Pipes**: The velocity of flow, rather than the flow duration, is the most critical factor in flushing water lines. The velocity within the pipe should exceed 3 feet per second (fps). To achieve this flow rate, the size of the flushing point may need to be increased or multiple faucets opened simultaneously. The blowoff size should be approximately as large as the pipe being flushed. Shown below are representative flow rates to achieve 3 fps. See fact sheet WD-DWGB-7-5 for details of distribution system blow-offs at www.des.nh.gov/organization/commissioner/pip/factsheets/dwgb/index.htm.

| Diameter (inches) | Gallons per Minute to Achieve 3 fps |
|---|---|
| 2 | 30 |
| 4 | 120 |
| 6 | 350 |

Do not flush muddy water through the storage tank or through distribution piping, if possible. Do not flush into streams or ponds; make a detention pond to receive this dirty water.

## ANALYSIS OF SYSTEM: WHERE TO ADD THE DISINFECTANT

The disinfection must be carried out either upstream or at the point where the bacteria entered the system. If there is not sufficient evidence to determine the entry point of the bacteria, you need to disinfect the entire system. If you can localize the origin of the bacteria entry, you only need to disinfect that component of the system and any remaining components down stream. If you find a construction defect, the defect must be repaired first before the disinfection.

## WHAT CHEMICAL TO USE TO DISINFECT

Chlorine is the standard chemical used to disinfect all components of a water system. Chlorine comes in two common forms: 5 ¼ percent sodium hypochlorite, a liquid; and $70^{\pm}$ percent HTH calcium hypochlorite, a solid. The liquid can be purchased at supermarkets and is commonly known as chlorine bleach (sodium hypochlorite). Read the label to ensure purchase of only sodium hypochlorite. The solid HTH can be purchased from swimming pool supply dealers in either tablet or granular form.

Some manufactures are producing 6 percent sodium hypochlorite bleach. If used, your solution will be slightly stronger than our calculations.

## DETERMINING THE VOLUME OF WATER NEEDING DISINFECTION

To determine the amount of chlorine to use, it is necessary to determine the volume of water in the facility(ies) to be disinfected. The volume of water in a circular shape can be determined by using the formula:

Volume (in gallons) = $n \times R^2 \times H \times 7.48$

Where: $n = 3.14$

$R$ = radius (in feet) of the well.

H = water depth (in feet) from water surface to bottom of the well.

Shown below are tables that provide the interior volume for various size cylinders.

## VOLUME IN WELLS

(Approximate Capacity of a Well in **Gallons**)

| | Diameter | | | | |
|---|---|---|---|---|---|
| **Water Depth (ft)** | **6 inches** | **1 foot** | **2 feet** | **3 feet** | **4 feet** |
| **2.5 *** | 4 | 15 | 60 | 130 | 230 |
| **5 *** | 8 | 30 | 120 | 260 | 460 |
| **10** | 15 | 60 | 240 | 520 | 930 |
| **20** | 30 | 120 | 470 | 1060 | 1880 |
| **100** | 140 | 590 | 2350 | - | - |
| **500** | 710 | 2950 | - | - | - |

* = to achieve minimal filtration of rainfall, the soil backfill around a well should be at least 5 feet above the water table.

Water also exists on the outside of the well hole in the crushed stone or rock faults. Depending on well type and depth, this amount of water can be large. We suggest doubling the volume determined above when considering the amount of water needing disinfection.

## VOLUME IN STORAGE TANKS

(Approximate Capacity of a Water Storage Tank in **Gallons**)

| | Diameter (feet) | | | | | |
|---|---|---|---|---|---|---|
| **Water Depth (ft)** | **2** | **3** | **4** | **6** | **8** | **10** |
| **2.5** | 60 | 130 | 230 | 530 | 940 | 1,470 |
| **5** | 120 | 260 | 470 | 1,050 | 1,870 | 2,940 |
| **7.5** | 180 | 397 | 700 | 1,580 | 2,810 | 4,420 |
| **10** | 240 | 530 | 940 | 2,110 | 3,760 | 5,880 |
| **15** | 360 | 790 | 1,400 | 3,170 | 5,630 | 8,810 |
| **20** | 470 | 1,060 | 1,880 | 4,230 | 7,520 | 11,750 |
| **30** | - | - | 2,820 | 6,340 | 11,280 | 17,630 |

In **atmospheric** tanks, assume the top **10** percent of the tank is air space. In **pressure** tanks, assume the top **30** percent of tank volume is air space.

**Equivalent Volume of Hypochlorite to Weight of HTH**

| Required 5.25% Hypochlorite | Equivalent 70% HTH |
|---|---|
| 1 quart | 2.2 oz by weight |
| 1 gallon | 8.9 oz |

**VOLUME IN DISTRIBUTION PIPES**

(Approximate Volume of Water in 100 Linear Feet of Pipe.)

| Inside Pipe Diameter (inches) | Gallons per 100 Linear Feet |
|---|---|
| 0.50 | 1 |
| 0.75 | 2.3 |
| 1 | 4 |
| 2 | 17 |
| 3 | 32 |
| 4 | 65 |
| 6 | 140 |
| 8 | 336 |

**CONCENTRATION OF CHLORINE TO USE**

The chlorine concentration used to disinfect water facilities can be varied based on the bacterial contamination level expected. If the water system is believed to be reasonably clean (no pipe breaks, no pipe replacement), then 5 parts per million (ppm) is a good disinfecting concentration. If stronger contamination is expected, then a 50 ppm concentration, or higher, should be used. In either case, flushing is a critical step before beginning the disinfection. For an additional reference, see American Water Works Association AWWA Specification C651-86 concerning disinfecting water works facilities.

Shown below are amount of chlorine to achieve various residual concentrations.

| Desired Concentration (ppm) | Store Bleach | Raw Water (gallons) |
|---|---|---|
| 1 | 1 gallon of 5.25% | 50,000 |
| 5 | 1 gallon of 5.25% | 10,000 |
| 50 | 1 gallon of 5.25% | 1,000 |

**Example:** Assume you have 2,500 gallons of water in a storage tank which you want to disinfect. The tank has been flushed to a high state of cleanliness and thus 5 ppm seems an adequate concentration of chlorine to use.

**Solution:** 2500 gallons /10,000 gallons = 25%
Use 25% of one gallon of store bleach; thus use one quart of 5.25 percent hypochlorite.

If the entire system will be disinfected, consideration should be given to the additional water in the tanks and piping.

**DISINFECTING THE SOURCE**

Before beginning the disinfection process, provide advance notice to customers that the water system

will be chlorinated. If dissolved iron or manganese is present in the water, expect staining complaints.

**Existing Dug Wells**

Remove the cover. Pour in the proper volume of chlorine. Mix by running a hose stream back from a sill faucet or pump house, into the well. Circulate the chlorine water solution through the storage tank, and distribution system. Measure the arrival of the chlorine by odor at user taps or by test kit determination. Let stand preferably overnight. Then, after contact time, flush the heavy chlorine to waste.

**Existing Bedrock Wells**

With bedrock wells there may be difficulty in dispersing the chlorine throughout the well depth.

When liquid chlorine is used, add water to the top of the well to force the liquid chlorine deeper into the drill hole. Typically a garden hose would be used to bring water from the pump station or home to the well. The water would be added to the top of the well until the chlorine odor is noted in the running water. This method is often used for a shallower well, less than 100 feet.

Solid chlorine tablets can also be used. The advantage of chlorine tablets is that they sink to the bottom of the well, fully dispersing the chlorine through the overall well depth. The tablets should be reduced in size by placing in a heavy bag and breaking with a hammer. Pour the dry chlorine pieces into the well. Let the chlorine set over night, and then proceed as indicated for shallow wells. This method is often used for wells greater than 100 feet deep.

If you have the ability to run water back into the well, either dry or liquid chlorine can be used.

## HOW TO TIME THE ADDITION OF CHLORINE

As a typical rule of thumb, the chlorine should be in contact with the system components overnight. The more contact time, the more assured the bacterial kill. Chlorine is normally added to a water system in the early evening. This allows the chlorine ample contact time for all facilities before being flushed out the next morning.

When a water system cannot be shutdown overnight, the chlorine residual will need to be re-strengthened as new water comes from the wells. The goal is to maintain a continuous level of chlorine through out the suggested 12 hour contact period. It is not necessary for the same chlorine atom to be in contact with a particular point in the system so long as the general chlorine concentration remains at an effectively high level. In a case where the system cannot be shutdown, the maximum tolerable chlorine level by customers is approximately 5 mg/L. DES suggests using double the calculated chlorine amount immediately and 1/6 of the calculated amount added at 3 hour intervals including 3 hour, 6 hour, and 9 hour points in order to replenish the chlorine which is being depleted. Other ratios and addition intervals are also acceptable.

## FLUSHING OUT THE CHLORINE

Early the next morning, the excess chlorine should be flushed to waste via a blow-off and/or hydrant. DES suggests flushing to waste until the free chlorine level is less than 1.0 mg/l free chlorine.

When flushing, it is preferable to run the flushed water into a sump in the ground. Do not directly dispose of the chlorinated water into a stream or pond as it will kill aquatic life.

## DISINFECTING OTHER COMPONENTS OF THE SYSTEM

Shown below are instructions for disinfecting other components of a public water system.

**Adding Chlorine to Water Storage Tanks**

Chlorine can be added to a non pressure tank through the air vent at the top of the tank. The equipment needed would include a funnel and flexible rubber or plastic small diameter tube. The flexible tube would be snaked through the vent, the funnel would be attached, and the concentration liquid chlorine poured into the funnel. Run the well pump(s) to help mix the chlorine and stored water.

For pressure tanks, it is normally easiest to add the chlorine to the well or vented storage tank prior to the pressure tank and then run the appropriate pumps to force the chlorinated water solution through the pressure tank. To feed chlorine directly into the pressure tank a chemical feed tap must be installed on the water feed line and a chemical feed pump must be purchased. Ensure that the chemical feed pump has a pressure capability comparable with that of the operating water pressure tank. The amount of chlorine added would recognize all volumes downstream of the injection point.

**Adding Chlorine to Piping Systems**

Chlorine can be added to the distribution system by attaching a chemical feed pump. The chemical feed pump would discharge into the water main through a tap similar to that used for a house service connection. The chlorine chemical feed pump would be run while water is flushed out through a hydrant or blowoff at the end of the distribution system. This configuration is similar to that used for pressure testing new water mains. Note that the service line must be filled with the chlorine solution before the chlorine will reach the main distribution pipe.

## NEW WELLS OR RECENT REPAIR OR CONSTRUCTION

In some cases bacterial contamination can be attributed to a one time event rather then to an ongoing deficiency in a facility. These one time events often include:

- Newly installed wells.
- Recent repair work performed on the well pump or pump station piping.
- Cleaning the water storage tank(s).
- Recent repair of water main breaks or extension of the water main.

In these situations it is critical to flush extensively, however a detailed inspection of the facilities may not be necessary.

## FOLLOW-UP ACTION

Bacterial sample(s) should be taken after the chlorine has been flushed from the system to ensure that the disinfection has been successful. Repeat the bacteria sampling the next month (or possibly even weekly) to insure that recontamination does not occur. Bacteria samples cannot be taken until all chlorine has been flushed away.

## FOR MORE INFORMATION

Please contact the Drinking Water and Groundwater Bureau and the New Hampshire Water Well Board at (603) 271-2513 or dwgbinfo@des.nh.gov or visit our website at www.des.nh.gov/organization/-divisions/water/dwgb/index.htm. All of the bureau's fact sheets are on-line at www.des.nh.gov/-organization/commissioner/pip/factsheets/dwgb/index.htm.

Note: This fact sheet is accurate as of January 2008. Statutory or regulatory changes, or the availability of additional information after this date may render this information inaccurate or incomplete.